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Face mask detection using Deep Learning Approach

[1]Hiral Talsaniya, [2]Dr.Dinesh Vaghela

[1]Scholar, [2]Assistant Professor, [1,2]Department of Information Technology, Shantilal Shah Engineering College, Bhavnagar, Gujarat, India. [2]dineshvaghela28@gmail.com, [1]hiraltalsaniya98@gmail.com

Abstract- During the year 2019-20 world has been affected by the corona virus disease. Due to the COVID-19 virus epidemic worldwide governments across the world impose lockdown to stop virus transmission. The WHO recommended wearing a face mask to reduce the risk of virus transmission while they gather at public places. According to WHO, wearing a face mask is an important step to prevent COVID-19 virus transmission. Hence, there is a need for monitoring each and every person in public areas if they are wearing masks or not. Therefore, Objective of this work is to monitor people in public places and to detect face masks on people who are partially exposed/ hidden by some other object or whose face is not fully visible and to detect the face mask of a rotated face. There are various deep learning algorithms for object detection like Different versions of YOLO, Fast R-CNN, Faster R-CNN, Region based R-CNN, SSD, etc.... Hence, the aim of this research work is to apply best deep learning algorithms to detect the face mask of rotated faces and partially hidden faces and will be able to classify people very efficiently even if people wear diversified face masks.

Keywords: Object detection, Face detection, detection, Face with masks, Deep learning, COVID-19 epidemic.

I.INTRODUCTION

The spread of COVID-19 virus globally in 2020 and the virus can be spread through contact with people. Due to the Covid-19 virus epidemic, governments around the world are implementing lockdowns to stop the transmission of the virus. Number of confirmed cases is increased in day to day life so it is necessary to aware people about their health and stop the spread of coronavirus with precaution. In this ongoing pandemic situation wearing masks is an important step[5]. The world health organization(WHO) has recommended to wear a face mask for the people to protect themselves while they gather at public places and reduce the transmission of COVID-19[5]. Because of this epidemic it is so important for people to wear masks that it is necessary to have a monitoring system. Therefore there are requirements to monitor the temperature of people and identify whether they wear masks or not.

Different policies were developed by policymakers to reduce the spread of viruses. Lots of challenges are faced by policymaker. laws forced people to wear masks when they go to public places. So it is a major challenging task to monitor the people in large groups. The process of monitoring involves the detection of people with mask and without mask.

Face masks provide some characteristics in COVID-19 situations. It helps people to reduce the transmission of coronavirus and protect the people's health. According to WHO for disease prevention and control[5], wearing a face mask in public, private places has been necessary to reduce the transmission of COVID-19,because those who are pre-symptomatic can spread the virus before showing symptoms. In the market different types of masks are available like surgical masks, N95 masks, cloth masks, etc. But, some masks are more effective than others.

The existing method is the manual detection of the face mask in the public, private sector by the police and group of people, it is a very laborious task and less accurate when monitoring the more number of people. Sometimes all the people in the public and private sector are not monitored successfully. Therefore, the automatic detection of face masks from images and videos is valuable to aid the government as it is more accurate and takes less time and effort. There are some techniques to detect face masks and classify the people with masks and without masks. But it can't detect the face mask of partially hidden faces or rotated faces. In Furthermore, the challenging part of this research work is not only detect people who wear mask and who doesn't wear mask but also detect people when face covered by hands and people wear diversified face mask at that time existing system can’t gives the accurate result of classification of people.

Deep learning can be used for detection of masks and/or classification of people with masks and people without masks. There are various deep learning algorithms for object (face with mask) detection like CNN, Fast R-CNN, Faster R-CNN[4], Region based R-CNN, SSD[1], different versions of YOLO[3],etc... Additionally, We develop models which are able to deal with complex images (like a rotated face, partially hidden face, faces covered by hands,

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people wear diversified face masks).

II.RELATED WORKS

In the meanwhile much work has been done for COVID-19 face mask detection. For the monitoring of people they have present model masked face detection. They have suggested cascade Convolution Neural Network(CNN). This cascade CNN operates on three different layers of CNN, for the identification of masked faces. They also worked on a self-created MASKED FACE dataset because the existing masked face dataset is inefficient to test[6]. In this paper they proposed a face mask detection system for health care people who are inside an operation theatre. In the operating room, health care personnel must wear a face mask, and the proposed system will alert anyone who is not wearing the mask. Their proposed method had a recall rate of 90% and a false positive rate of more than 5%. They are only useful for detecting medical masks in photographs taken from a distance of 5 meter by cameras[7]. RetinaFaceMask is a face mask detection model which combines with a cross class object removal algorithm. It provides higher recall and precision than the baseline result because it contains one stage detector consisting of a feature pyramid Network[8]. They worked on the face detection from the images. They captured images from the video and then detected the faces of people whose face is covered by a mask. From the detected masked face images original images are detected. They have proposed SVM for classification and Multi task Cascaded CNN[9]. In this paper mask face detected using 4 different types of approach.a)distance from camera.b)eye line detection.c)Facial part detection.d)eye detection.In this based on the features classifies the image using Viola Jones face detection. For person detection they use HOG algorithms. Using Viola Jones algorithm facial features are detected like eye,nose,mouth. Viola Jones algorithm false positive rate is low and true detection rate is high. For the classification purpose they use AdaBoost learning algorithms. In eye line detection, the false detection rate is very high. It gives the accuracy for different algorithms (Distance from camera- 90% accuracy, Eye line detection-69.8% accuracy,Facial part detection – 46.6%,Eye detection – 40%). But it is a very robust and time consuming process and it can not give an accurate result when the image is in poor resolution[10]. Another work done in this field is detection of masked faces. It contains two main tasks:1)Object detection and 2)image completion. So,first they detect the face and detect the mask region of the face. Take the image as input and find a binary map of the face mask region that is given as input to the GAN network and generate an image which does not contain a mask. For mask detection it uses a selective search algorithm for extracting regions from images. From the extracted features SVM classifies the availability of objects within candidate regions. They did not provide accuracy of mask face detection[11]. They worked on Viola's face detection system, which is a reliable and quick method. This algorithm uses a skin mask to identify faces and produces results four times faster. To reduce the false detection rate, the training is performed for modelling systems with one eye or two eyes and one nose. They got 2.4 % false negative[12]. They have worked on multiple face detection models based on machine learning algorithms like Haar boost, Ada-Boost,Support Vector Machine(SVM) and gradient boost models. These techniques work very efficiently but the major challenge faced by the researcher is that the false positive rate is very high in certain facial data[13]. They use deep learning based CNN models for face detection from images. Face mask detection is created using 2 models.1)face detection model which is used to detect the faces from the image. 2)mask detection model which is used to detect the mask of face in image. This approach is not applicable to detect the face mask when face cover with mask like object such as scarvers,medical mask,etc. It means it is not applicable to detect all types of masks. CNN is also used in this paper for classification and detection. This work had been done on (380 images with mask and images without_mask)dataset. This face is not detected when the height of the camera is greater than 10feet. Face is partially hidden by a person or some object at that time this model is not able to detect the mask and is not able to classify images[14]. They have used deep learning based pyramid boxes for face detection. They achieve 96.5% accuracy. They give accurate results for front face recognition. More training data is required to make the system more stable and efficient. When faces are small and there are more faces in images,the recognition system is not accurate[15]. They use CNN for face detection from images.

The trained model achieved 98.7% accuracy. Their proposed system does not classify properly when faces are covered by hands. Classifying the face of each person is very difficult in densely populated areas[16]. They use YOLOv3 Tiny[2] for face mask detection in images. System performs well in people's front faces. Model cannot be able to differentiate a portrait sculpture and a real person[17]. They have proposed SSDMNV2. For face detection Single Shot Multibox Detector and for the classification MobilenetV2 architecture used. They have obtained 93% average accuracy. But Real-world implementations will be a much more difficult problem in the future. [18].

Table-1 Literature Table

Method/Model	Findings	Dataset Details	Accuracy
R-CNN[2][11]	Large Training samples are require Extract region using selective search	-	-
D[2][18]	Real-world	5521	93%

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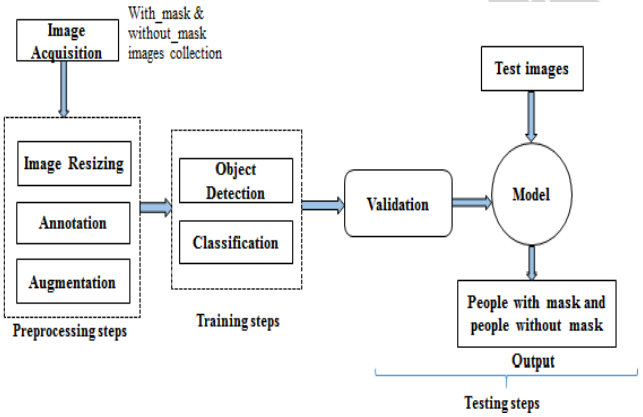
	implementations will be a much more difficult problem in the upcoming future	images	
CNN, MobileNetV2[14]	Face is partially hidden by some object so that it can't detected	4225 image	97%
Pyramid box[15]	The front recognition is accurate but side view images detection is not. More training data require when the face is small and more, the recognition is not accurate.	-	96.5%
YOLOv3-Tiny[2] [17]	System performs well in people's front faces. Model cannot be able to differentiate a portrait sculpture and a real person	68 (withmask) 544 (without mask)	Focus on accuracy of detection
CNN[16]	difficult to classify faces covered by hands since it almost looks like the person wearing a mask. distinguishing the face of each person is very difficult in a very densely populated area.	858 (withmask) 681 (without mask)	98.7%

III . PROPOSED METHOD



The proposed workflow consists of the following stages: Collecting mask and without mask face without mask images, pre-process them and finally train the model for the acquired dataset . All of these phases are described in detail as following:

A Image Acquisition

According to WHO (world health organization)wearing the mask is a very important step to stop transmission of corona viruses in this COVID-19 pandemic situation. There are various places at which people have to wear masks; such as Hospitals, School, Airport, Railway station, Bus station, Shopping Mall, Temple, So, we need images of all types of masks and images with blurred face, rotated face and hidden faces. Images collected from three different sources to form dataset for training our models, those are taken from following:

1. Real condition images: Images are captured from Bus stand,Hospital,road,railway station
2. Face mask dataset: Face with mask and without mask images captured from open datasets
3. Images downloaded from the various Internet resources:Images of different places like Hospital, Airport,Road, etc..,are downloaded from the websites

B Pre-processing

Image Resizing

All images are taken from different sources as described in the above section. Therefore, all images are in different sizes and it is important to resize images in the same size while giving the database as input while training the model. Image resizing process in which all images in the dataset are resized to the same size.(depends on model).

Data Augmentation

Data augmentation is used to reduce overfitting problems in deep learning models. Images in the test dataset may be in a different type of condition, for example orientation, location, scale and brightness. This technique is used to increase overall performance by generalizing the model. The main goal of this process is to train the model to learn those features, which are unique to each class and helps to discriminate against one class. Various types of techniques can be applied to the dataset of training images like rotation, flipping, zooming, and shearing. The augmentation methods make a good generalization of the model.

Data Annotation

In object detection models, it is important to give labels to each object of image to process those images accurately. Therefore, we should manually annotate the areas of each image which consists of the mask or without mask with a box using labelImg tool[19]. So, it is important to get expert advice to identify the people who wear mask and who does not wear mask. This advice can be helpful to distinguish the objects in the images and assigning label to each of them.

The annotation process is used to give labels to each face and area of the mask in the image. The outputs of this step are the x and y coordinate values of the bounding boxes which can be of different sizes and class of mask. The Intersection-over-Union (IoU) is used to evaluate ground truth bounding boxes with the predicted values of the

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network while testing. Since some of the images are collected in the real conditions, some faces are blurred in images and some are hidden faces and rotated faces and faces who wear different types of masks to make the problem more challenging. If annotations are wrong in some images, the model will learn wrong features and it results in wrong detection which ultimately reduces precision and accuracy of our model. Therefore, it is vital to give accurate knowledge to the model and the annotation process is very important in the whole implementation phase.

C Training Phase

The CNN model is able to classify the mask and unmask people as per the classes mentioned in the training. We have applied Yolov2, YOLOv3, YOLOv4, ,YOLOv5 for the training of our dataset. Object detection models such as YOLOv2,YOLOv3,YOLOv4,YOLOv5 need CNN for classifying the objects they have detected depending on models' individual processes. After implementing the work for one person, the process can be implemented for more face masks, so we will include more images from the face mask datasets, more real life condition images and the images downloaded from the Internet. So, we are using transfer learning with object detection models and CNNs as it provides more accurate results and saves time than doing training from scratch and using custom CNNs.

D Testing Phase

We have tested different real scenario images so we are able to know how system work in real life.Our proposed system able to detect the rotated faces,partially hidden faces and people who were diversified face mask and also able to detect the person and classify the people with mask and without mask in very densely populated area as well as our model can detect the face mask of skin color.

As per below Fig 1 Our approach is able to detect and classify rotated face mask and hidden face mask.

Figure 1.Partially Hidden & rotated face mask detection

Below Fig 2 people wear skin color face masks still we are able to classify properly whether a person wears a mask or not.

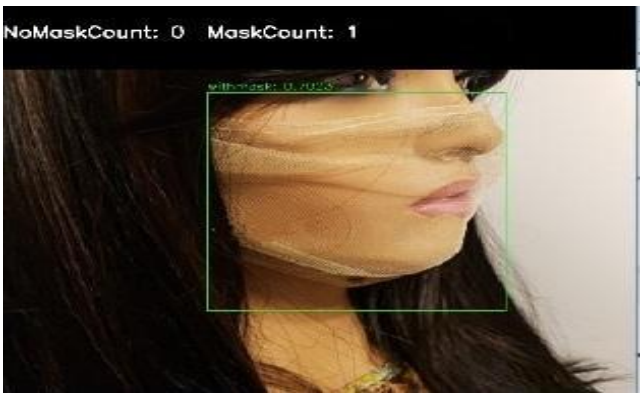

Figure 2. Skin color face mask detection

Below Fig 3 shows the person's face is covered by hand but the person wears a mask then it also classifies properly and finds whether the person wears a mask or not.

So we can say that our approach also classifies and detects properly when the face is covered by hand.

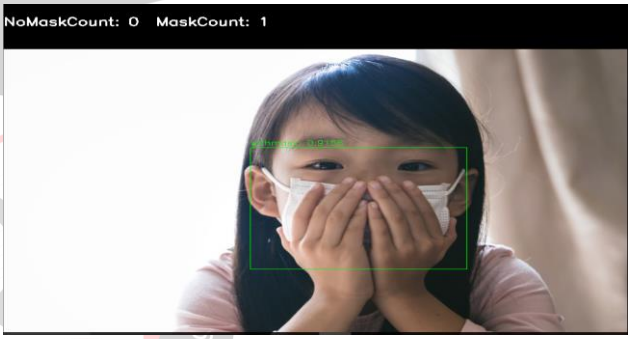

Figure 3. Face covered with hand Detection

There are different types of masks available in the market. Different people wear different types of masks as shown in Fig 4 still we can identify people with masks and without masks and classify properly. We also provide the total number of people who wear face masks and number of people without mask in very densely populated area.

Figure 4. Diversified face mask detection

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Table 2. Different Version Outcomes Comparison

Object Detection	Time (sec)	Accuracy (%map)	Recall
YOLOv2	22	89.95% (0.899529)	86.29%
YOLOv3	31	94.47 % (0.944726)	96.82%
YOLOv4	32	96.07% (0.960692)	98.62%
YOLOv5	30	99.45 (0.9945)	99%

In Table 2. We have compared mAP and recall generated by different versions of YOLO like YOLOv2,YOLOv3, YOLOv4 and YOLOv5.

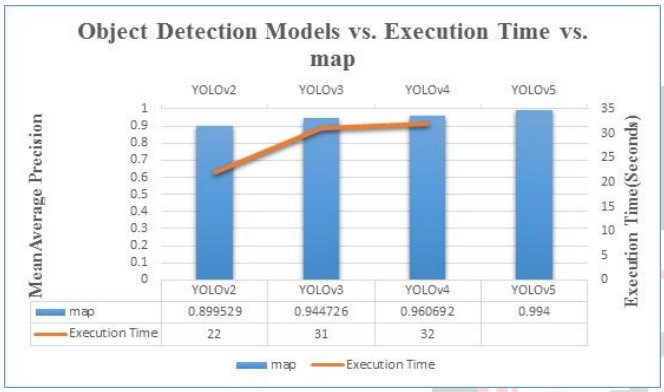

Figure 5. Model mAP comparison Graph

In the above graph we compare the accuracy of different versions of YOLO and find out which gives the best mAP and solve all the research gaps of previous work.

IV.CONCLUSION

Face mask detection is one of the greatest real world challenges. I have found out from the research gap that existing methods are not able to detect the face mask of rotated face, partially hidden face and diversified face mask and skin color face mask. So in this paper we have improved the algorithm based on different versions of YOLO and have proposed a solution to solve the research gap. We have created our own COVID-19-Mask dataset. In order to detect whether people are wearing masks or not, the system will be able to detect face masks in real life scenarios. We have Compared YOLOv2,YOLOv3 and YOLOv4,OLOv5 on our dataset. Based on our experiment and result analysis we have find out that our proposed solution is able to detect the face mask of partially hidden face , rotated face and also able to detect the skin color face mask and properly classify people with mask and without mask when face covered by hand and people wear Diversified face mask. YOLOv5 gives the highest accuracy compared to other versions of YOLO. And it gives a more accurate result in the real world scenario for face mask detection. It can be further extended by integrating it with alarm and temperature detection and also apply the same approach on surveillance cameras.

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